BAA-2003-1 **Appendix C**

NEXT GENERATION HIGH-SPEED RAIL TECHNOLOGY DEVELOPMENT PROGRAM OVERVIEW

INTRODUCTION

Mobility between major urban areas is vital to American society. But highways and airport facilities on critical intercity corridors around the nation are suffering unacceptable congestion as travel demand grows. Construction of new limited access highways can cost $40 million per lane mile, and airport expansion is often not feasible because of surrounding development.

High-speed ground transportation systems, such as those that have been built in Europe and Japan, provide superb service quality, but implementation of such systems in the United States has been prevented by high costs and the difficulties associated with acquiring new right-of-way. The Next Generation High-Speed Rail (NGHSR) Program seeks to demonstrate that the public will welcome incrementally upgraded High-Speed Rail (HSR) passenger service which has air or road competitive door-to-door trip times between major city pairs and reliable, high quality, cost effective service.

Existing railroad routes provide an attractive, practical alternate to meet present and future mobility demands in corridors connecting major urban areas up to 400 miles apart. Technology is presently commonly available to operate trains at speeds up to 110 mph and Acela trainsets are now providing 150 mph service on the Amtrak Northeast Corridor. These technologies can provide competitive intercity trip times on the order of three hours in selected corridors.

A number of State Departments of Transportation are implementing or considering implementing high-speed ground transportation systems on existing rights-of-way as a viable alternative to increased investment in intercity highway and airport capacity. For example, the State of Florida no longer permits freeway expansion to more than 6 through lanes plus 4 specialized lanes.

As mandated by Congress, the Federal Railroad Administration (FRA) performed a commercial feasibility study (CFS) of high-speed ground transportation. The CFS results are summarized in a report titled High Speed Ground Transportation for America (U.S. Federal Railroad Administration, Sept. 1997.* Estimated costs from the CFS and similar State-sponsored studies are $300,000, $550,000, $3 million, and $5 million per mile to upgrade existing railroad to operate at 90, 110, 125 and 150 mph respectively.

Further technology development and demonstration is needed to provide cost effective high quality service in applications in the U.S. FRA has identified four program areas where development and demonstration activities have a high potential return on investment when upgrade programs are implemented:

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* The CFS report is available from the FRA Internet web site at http://www.fra.dot.gov/rdv/hsgt/cfs/index.htm.

Advanced Train Control systems particularly suited to maximizing the capacity of railroads to carry a mix of high-speed passenger, commuter, and freight trains with minimal risk of collision and implemented at considerably lower cost than conventional methods of upgrading railroad signal and control systems to support high-speed operations.

Non-Electric Locomotives to achieve the speed and acceleration capability of electric trains without the expensive infrastructure of railroad electrification.

Grade Crossing Hazard Mitigation, including barrier systems and innovative warning devices and methods that provide nearly the same security as grade separations but at much lower cost.

Enhanced Track and Structures to cost effectively increase route capacity and/or improve performance of the infrastructure on existing corridors to be sufficiently robust to permit shared heavy freight and high-speed passenger use with satisfactory ride quality.

At the same time, we have an opportunity to take advantage of technology developed largely for defense applications now finding new uses in high-speed rail, such as the Global Positioning System (GPS) satellites* for automatic train location and high strength lightweight materials to reduce train weight and improve performance.

The NGHSR Technology Development Program is built around these concepts to make available new technology and devices that are particularly suited to U.S. applications for near-term implementation of high-speed rail by the States. Federal sponsorship of the program is necessary because no single state or region in isolation can afford the necessary technology development efforts. The railroad supply industry perceives the market to be too small to independently fund technology development costs until several corridor upgrades are underway to substantiate that the market is of reasonable size.

The NGHSR Program is based on partnerships with suppliers of technology, railroads, and State governments. By working with State and railroad partners we will be providing a real-world environment for the application of these technologies, preparing the way for a smooth introduction when States are ready to implement their systems. The NGHSR sponsors research to enhance HSGT development through its Broad Agency Announcement, which will make up to $6.5 million available in FY 2003.

PROGRAM OBJECTIVE

The specific objective of the NGHSR Program is to support the availability of cost effective high-speed technology on existing infrastructure, with a target of permitting cost effective upgrades to high-speed service, relying on proven technologies, in the range of $2 million to $3 million per mile.

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* Further information is available on the FRA website at www.fra.dot.gov/rdv30/ndgps/ndgps_its.htm.

The Amtrak Northeast Corridor (NEC) presently provides the only high-speed rail service in the nation.

Since its inception in FY1995, the program has been funded at approximately $20 million per year. The breakdown within categories, the number and type of categories along with the funding sources has varied somewhat during the period.

EXISTING HIGH-SPEED RAIL DEVELOPMENT EFFORTS

The states that have already initiated HSR development programs include: California, Florida, Illinois, Michigan, New York, North Carolina, Oregon, Virginia, and Washington. A majority would begin with incremental service around up to 110 mph. Such service would likely be over existing track also used for freight. In addition to the states listed above, the Transportation Equity Act for the 21st Century (P.L. 105-178), passed by Congress in 1998, formally designated, as developing high-speed rail corridors, the Empire Corridor in New York State, the Keystone Corridor in Pennsylvania, and the Gulf Coast Corridor in Texas, Louisiana, Mississippi, Alabama, and Florida. The Midwest Regional Rail Initiative proposes to expand the previously designated Chicago Hub developing corridor to nine Midwest states. U.S. Department of Transportation recently extended existing ISTEA corridor designations to include additional cities in the nine-state Midwest initiative territory; extended the Southeast Corridor to cities in Georgia and South Carolina; and formally designated new corridors between cities in Texas, Oklahoma, and Arkansas and between Boston, MA, Portland, ME, and Montreal.

TECHNOLOGY OVERVIEW, PROJECT SUMMARY, AND SPECIFIC PERFORMANCE TARGETS BY PROGRAM AREA

ADVANCED TRAIN CONTROL

State-of-the-art Technology - 1998

For 79 mph or less: Train is located by detection circuits wired to track; engineer observes wayside signals and complies with their visual indications; no onboard equipment or enforcement (90% of U.S. track miles)

For 80 mph to 125 mph: Train is located by track detection circuits; wayside signal indications relayed into cab through electrical pulses in rail; train control based on electrical pulses in rails; onboard system enforces speeds, stops train if engineer does not comply (Amtrak NEC, selected other main lines)

. **Advantages:** Proven technology

Disadvantages: Costly to install and maintain, existing systems not fully interoperable (i.e. CSX locomotive cab signal system works on NEC, but does not work with Union Pacific control system.)

GOAL

High-speed Positive Train Control (HSPTC) - 2001 first service (90 mph revenue service began in early 2002 on a segment of the Detroit-Chicago Corridor).

Onboard equipment automatically locates train; digital radio links train with control system; onboard computer and database check for unsafe operations and stop train if necessary.

Advantages: No wiring to track reduces installation and operation cost; with foresight systems can be made interoperable; will ultimately permit higher track capacity using 'flexible blocks' rather than 'fixed blocks' tied to existing wayside signal spacing and track segments.

Disadvantages: Computer and communications integrity must be established for all operating situations.

APPROACH

Technology: Automatic location is done by Global Positioning System (GPS) augmented to obtain necessary accuracy; digital data radio links computers aboard train and along wayside; onboard computer uses onboard database to compare actual location and speed with radioed status information and/or authorities; system stops train if engineer does not comply.

Demonstration systems:

<u>Incremental Train Control System (ITCS):</u> taps existing signal system for status information; radios to train; onboard computer combines status, automatic location, and database information to inform engineer of safe operating limits; stops train if unsafe operation is attempted. System is in revenue service on Amtrak-owned line in Michigan. Installation is complete on the 80-mile demonstration territory and 45 miles are in service; cutover testing is underway on the remainder. Safety verification is underway. Accomplishing revenue service speeds of 90 mph was completed in January 2002; full safety verification and validation is targeted for 2004, to permit speeds up to 110 mph. NGHSR funding totaling $14.508 million has been awarded through FY 2003. Michigan DOT (MDOT), Amtrak and Harmon Industries have contributed over $20 million in cost sharing.

<u>North American Joint Positive Train Control Program (NAJPTC)</u>: project jointly funded by AAR, Illinois DOT (IDOT) and FRA is installing a system to support revenue-service high-speed operations and to demonstrate flexible-block operation using movement authority commands radioed to each train on a 123-mile track segment of Union Pacific Railroad’s Chicago - St. Louis Corridor and will establish industry-wide standards for control system interoperability. The overall effort is managed by a joint program office at the Transportation Technology Center (TTCI). A team led by Aeronautical Radio, Inc., (ARINC) serves as System Engineer. A $34 million System Design and Integration (SDI) contract was awarded in June 2000 to a team led by Lockheed Martin to design and install the demonstration system in Illinois. The target is to have the system installed and fully safety validated so that Illinois and Amtrak can begin revenue high-speed passenger service in December 2003. FRA has funded $39.25 million through FY 2003. IDOT has committed $12 million in cost sharing for the project. AAR has committed $20 million to be funded by its member railroads over a four-year period beginning in 1998. Total project cost over four years is estimated at $70 million. In parallel with the baseline effort, the signal system on the demonstration territory will be upgraded to a modern microprocessor and digital-radio-based signal system.

Crosscutting research:

Railroad Radio Communications Demonstration: A cooperative agreement for $2.75 million was awarded to the State of Oregon in FY 1997 to demonstrate advanced digital radio communication methods that will be the underpinning of communications-based train control systems, to assess communications integrity for urban/heavy traffic environments, to assure interoperability, and to assess corridor capacity to accommodate passenger and freight traffic simultaneously.

NON-ELECTRIC LOCOMOTIVE

State-of-the-art Technology - 1998

For 110 mph or less: Diesel-electric locomotives, such as the General Electric AMD-103 or the General Motors F-59 are used. Acceleration capability limits them beyond 100 mph.

For 110 mph to 125 mph: Electric locomotives are used on the Amtrak NEC; the upgraded Amtrak/FRA/NYSDOT Turboliners can operate up to 125 mph but acceleration is limited.

Advantages: Proven technology; reliable, maintainable; electric locomotives have greater acceleration capabilities.

Disadvantages: Electrics require catenary at $2-3 million/mile; conventional locomotives limit service quality by extending trip times and are heavy, wearing out track.

GOAL

High-speed Non-Electric Locomotive - 2003 demonstration service

Increased self-contained power supply and/or reduced weight permit locomotive to accelerate rapidly, both to reach initial speed and to recover after slowing for curves.

Advantages: Substantially reduced trip times result from increased average speeds; installation of catenary is not required; technology has dual-use with Defense and export potential.

Disadvantages: New technology must be proven to be economical, reliable, maintainable, environmentally acceptable or beneficial.

APPROACH

Technology: Turbine prime mover can provide very high power in small space with light weight and low emissions. Alternating current (AC) electronic transmission system within the locomotive uses advances in power electronics to increase efficiency, flexibility, reduce weight. Energy storage devices can substantially increase short-term acceleration capability.

Demonstration systems:

FRA/Bombardier Advanced Turbine Locomotive: Construction of a 5,000 horsepower 150 mph turbine-electric locomotive was completed in November, 2000 and it has completed high-speed qualification testing at TTCI in Pueblo, Colorado. Demonstrations on high-speed corridors are planned for 2003. FRA awarded a cooperative agreement to Bombardier, Inc. in FY 1998 to produce and demonstrate the locomotive, initially at 125 mph and ultimately at 150 mph. Total cost of designing and constructing the locomotive is $26 million, which has been funded equally by Bombardier and FRA through FY 2003.

Advanced Locomotive Propulsion System (ALPS) Project: is producing a very high power generator to be direct-driven from a turbine engine, and will use carbon fiber composite flywheel energy storage "battery" to substantially increase the acceleration of the turbine-powered locomotive. The ALPS team is lead by the University of Texas Center for Electromechanics. As of March 2003, the turbine-driven alternator, motor/generator, flywheel battery and power converter are being fabricated and tested. The high-speed generator final rotor build is proceeding on schedule and testing is expected to resume in the summer of 2003. The flywheel Motor/Generator is expected to be complete in the fall of 2003 and the flywheel power converter is also expected to be complete and undergoing final testing in late 2003. The ALPS project is planned for completion in the fall of 2005. A total of $22.95 million of Federal funds has been provided through FY 2003; $5.9 million has been requested for FY 2004.

RTL Turboliner Enhancements: With New York State DOT (NYSDOT), reliability and maintainability demonstrations of enhanced turbine-powered trainsets were conducted to assure that promise of new technologies can be delivered in practice. Under NGHSR, one trainset was upgraded with higher horsepower to Turboliner RTL-2 configuration and has operated successfully in revenue service since 1997. To achieve further improved acceleration in an RTL-3 configuration, FRA awarded $12.5 million through FY 1998, equally matched by NYSDOT. SuperSteel Schenectady received the upgrade contract in FY 1997. Under separate funding, NYSDOT and Amtrak have now committed to upgrade all existing seven RTL trainsets to the RTL-3 configuration, successfully completing the NGHSR demonstration phase and moving to implementation under separate funding. Two of the seven RTL-3 trainsets have been completed, tested and are expected to enter revenue service in late 2003.

Crosscutting research:

Upgrade is complete of 165 mph test track at Transportation Technology Center to assure availability of test site (complete).

Identify and develop new concepts that significantly increase performance.

Investigate and demonstrate noise and vibration suppression methods.

Investigate lightweight materials to reduce train weight while assuring crashworthiness for occupant protection.

GRADE CROSSING HAZARD MITIGATION

State-of-the-art Technology - 1998

For 110 mph or less: Grade crossings are permitted. States and railroads cooperate to determine protection levels including passive crossbucks, flashing lights, two quadrant gates (close only 'entering' lanes of road.) Lights and/or gates activated by circuits wired to track.

For 110-125 mph: FRA permits crossings only if "impenetrable barrier" blocks highway traffic when train approaches. Above 125 mph, no crossings will be permitted.

Advantages: Proven technology

Disadvantages: Permits highway vehicles to intrude in front of or collide with side of train; costly to install and maintain.

GOAL

Acceptable Grade Crossing Risk Level - 2003

Crossings eliminated whenever possible; advanced train control systems supply train location and speed information to activate warnings; onboard warning systems assure crossings are clear after gates or barriers are in place.

Advantages: Barriers limit risk to passengers and employees on high-speed train; no wiring to track reduces installation costs; onboard warning permits train to stop if crossing is blocked.

Disadvantages: Barriers must close well in advance of train arrival to confirm crossing is clear and permit train to stop if necessary; mechanical systems will be costly and must be maintained; barriers may damage motorists who ignore warnings.

APPROACH

Technology: Advanced train control systems will monitor and communicate train locations and speeds and will stop train if crossing warning devices are not functioning properly. Four quadrant gates (block all highway lanes) provide increased protection with existing technology. Movable barriers will protect crossings that cannot be closed. A comprehensive risk-reduction strategy is being defined and will be applied based on risk estimation models which consider actual traffic on highway as well as estimating the actual risks to both highway vehicle and train occupants.

Demonstration systems:

Michigan ITCS Demonstration: (described above under train control) includes upgrade of 57 public grade crossings to provide constant warning time and improvement or elimination of 21 private grade crossings. System linking crossings to locomotives via the positive train control system is in daily revenue service operation as of April 2001.

North Carolina's "Sealed Corridor": surveyed all grade crossings on the Greensboro to Charlotte developing high-speed corridor and is applying appropriate cost-effective techniques to mitigate and/or eliminate risk at each crossing. Federal funds totaling $12.63 million from the NGHSR and TEA-21 Section 1103 Grade Crossing programs have been provided through FY 2003. Monitoring has been conducted documenting the effectiveness of alternative crossing warning methods and installation of the selected methods has been completed. The methodology will be documented and made available for use on other corridors. As requested by Congress, FRA and NCDOT have published a report summarizing the effectiveness of measures taken to date in the form of lives saved; preliminary results show that 5 lives have been saved to date and accident reduction is sustainable over time, so many additional lives will be saved in the future.

"Dragnet" Barrier Systems: Operation and evaluation of three "dragnet" systems, which could physically stop intruding vehicles, began early in 1999 on the Chicago - St. Louis corridor in Illinois. The state concluded that the barrier systems were too maintenance-intensive to continue in operation and the systems will be removed.

Other innovative concepts are being sought for integrated demonstration and assessment for efficacy on revenue corridors through the National Academy of Sciences Innovations Deserving Exploratory Analysis (IDEA) Program and through broad agency announcements (BAA).

Crosscutting research:

Assess driver reaction to extended crossing closure times. Identify and develop effective, practical, economical barrier designs.

ENHANCED TRACK AND STRUCTURES

State-of-the-art Technology - 1998

Most existing freight railroad track uses wood tie construction with increasing amounts of concrete ties, particularly in territory with heavy curvature.

Track maintenance is based on manual inspections for exceptions to railroad and/or FRA Track Safety Standards. At each carrier's option, manual inspections may be augmented with periodic continuous track geometry car inspection runs on frequencies ranging from bi-annually to monthly on the highest density lines.

Advantages: Proven technology, many years of optimization to reduce incurred costs

Disadvantages: Freight and conventional passenger operations at up to 79 mph tolerate too wide range of track geometry variations compared with the more precise geometry required for satisfactory ride quality for high-speed passenger operations. Maintenance costs may increase unreasonably if conventional approaches are attempted to sustain necessary high-speed operational limits.

GOAL

Lower Cost of Upgrading and Maintaining High-speed Tracks - 2003

Identify new technologies, methods, and materials suitable to meet high-speed requirements; assess suitability of upgrading use conditions and maintenance practices so that existing conventional track provides acceptable technical and cost performance in high-speed passenger service, and/or more cost-effective techniques to construct necessary additional trackage to increase corridor route capacity.

Advantages: Potentially reduces a major cost element for corridor upgrades to higher speeds.

Disadvantages: New technology must be proven to be economical, reliable, maintainable, environmentally acceptable or beneficial.

APPROACH

Technology: Identify and demonstrate advanced inspection and maintenance practices which cost-effectively permit existing track structures and materials to meet high-speed requirements so that corridor trains can operate at sustained high speeds over the greatest portions of corridor lengths, thereby delivering minimum trip times on a reliable basis.

Demonstration Projects:

Infrastructure Upgrade on the Pacific Northwest Corridor: A cooperative agreement for $5.2 million was awarded in FY 1997 to the State of Oregon for track, grade crossing, and structures improvements to the developing high-speed corridor between Eugene, OR, Portland, OR, and Vancouver, WA. These improvements are complete.

Subgrade Mitigation Techniques: A contract for over $400,000 was awarded in FY 1997 to Foster-Miller, Inc., to demonstrate advanced techniques to resolve longstanding subgrade problems which degrade ride quality and threaten the operational safety of high-speed track and which cause excessive maintenance requirements and expense. An innovative mitigation technique employing grout injection was applied to a test zone on MBTA near Boston in early 2000; results to date show a marked reduction in track settlement and in maintenance required.

Increase Operating Speeds While Improving Ride Quality Over Bridges: A contract for $360,000 was awarded to the University of Delaware to develop techniques to improve ride quality and increase permissible operating speeds over bridges. These low-cost techniques have been successfully demonstrated on the Northeast Corridor and the Norfolk Southern and are now being employed by Amtrak.

Concrete Slab Track Demonstration: A contract for $940,000 was awarded to the Portland Cement Association (PCA) to install two sections of concrete slab track at the Facility for Accelerated Service Testing (FAST) track at the TTCI in Pueblo, Colorado. Slab track offers the potential to provide sustained improved ride quality with reduced maintenance requirements if it can survive the rigors of use by heavy freight trains. The FAST track provides intense controlled freight traffic loadings from an actual freight train operated repeatedly over a short loop of track.

Crosscutting research:

Inspection systems to assure cost-effective compliance with newly developed FRA high-speed track safety standards.

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